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(54) Method of manufacturing a hollow vehicle frame component having a sharp bend

(57) A method of manufacturing a hollow vehicle frame component having at least one relatively sharp bend may include the initial step of pre-forming a generally linear, hollow member into a desired configuration. The hollow member (15) may be expansion shaped by a hydroforming process. Next, a section (20, 21) of the hollow pre-formed member (15) is removed at a location where it is desired to be provide a relatively sharp bend. The section (20, 21) is removed along a portion of the pre-formed member (15) so as to divide it into two sections, thereby forming a hinge-like structure (23) therebetween. The two sections are then bent toward one another such that the edges (20a, 21a, 20b, 21b) adjacent the removed section are moved toward one another. Finally, the adjacent edges (20a, 21a, 20b, 21b) are secured together to form the vehicle frame component. Portions of the edges (20a, 21a, 20b, 21b) may abut one another or overlap one another for securement. A plurality of such bends may be formed in the hollow member (15). The ends (11, 13) of the hollow member (15) may extend within a single plane or within different planes. The magnitude of the angle formed in the member (15) is dependent upon the size of the section (20, 21) which is removed therefrom.

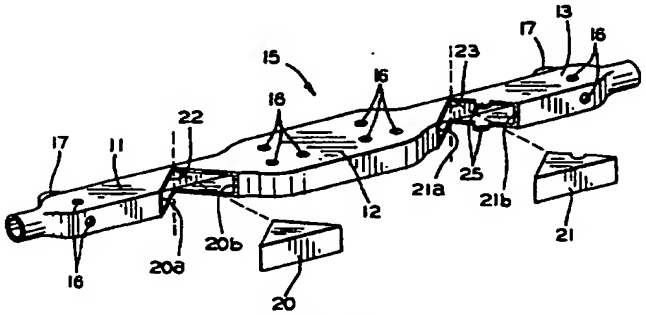

FIG. 3

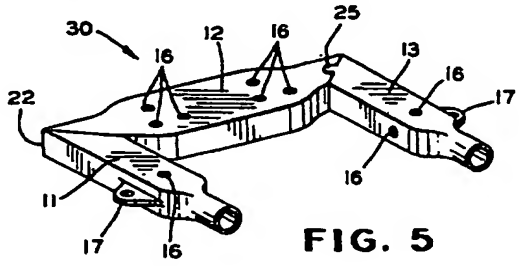

FIG. 5

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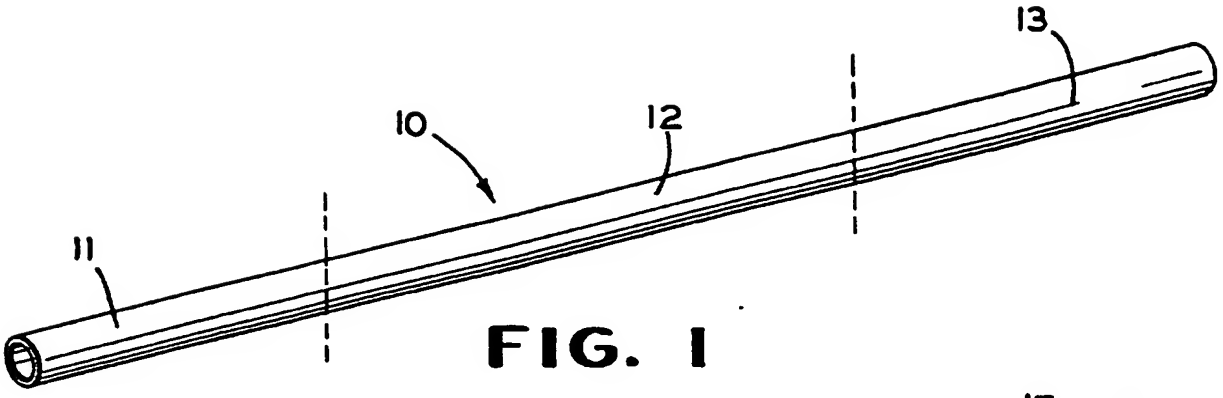


FIG. 1

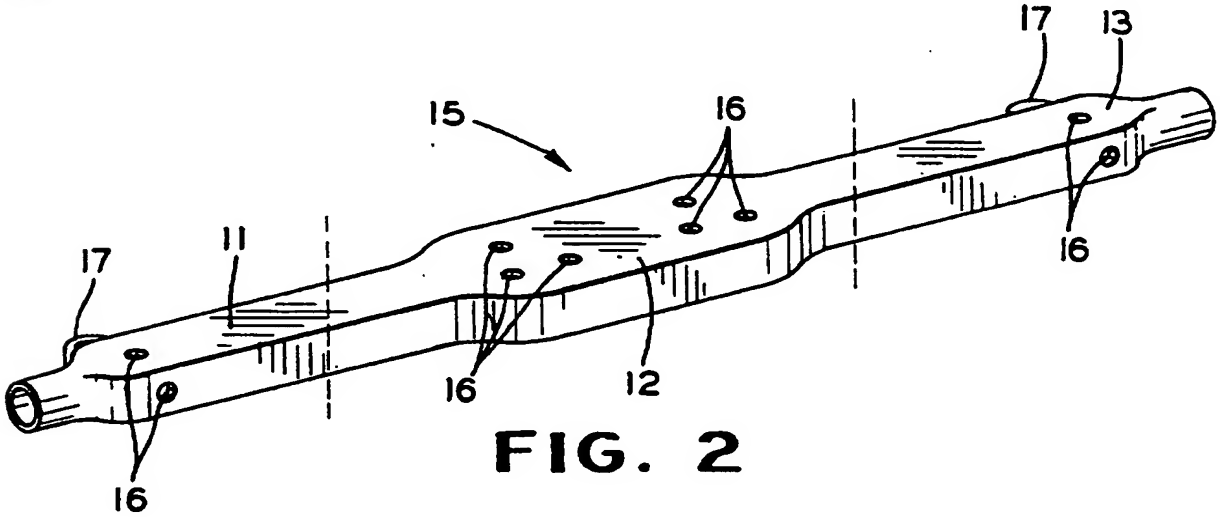


FIG. 2

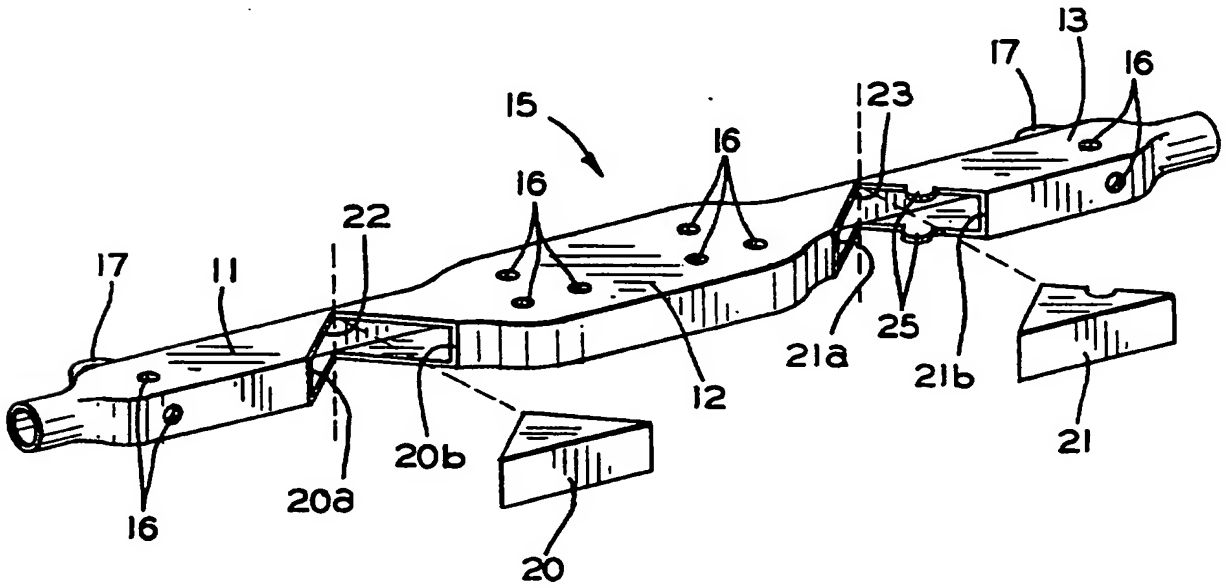
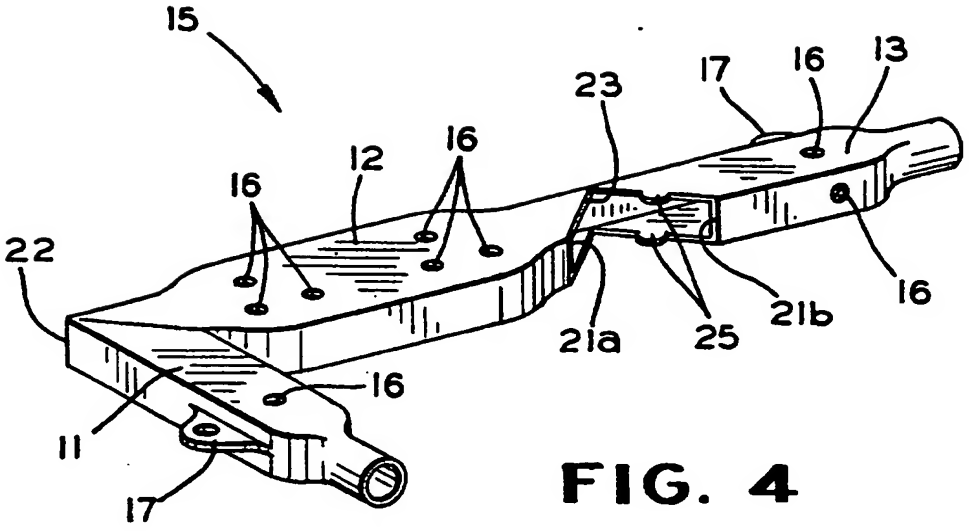


FIG. 3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16
13
12
16
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22
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21a
25
21b
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11
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FIG. 4

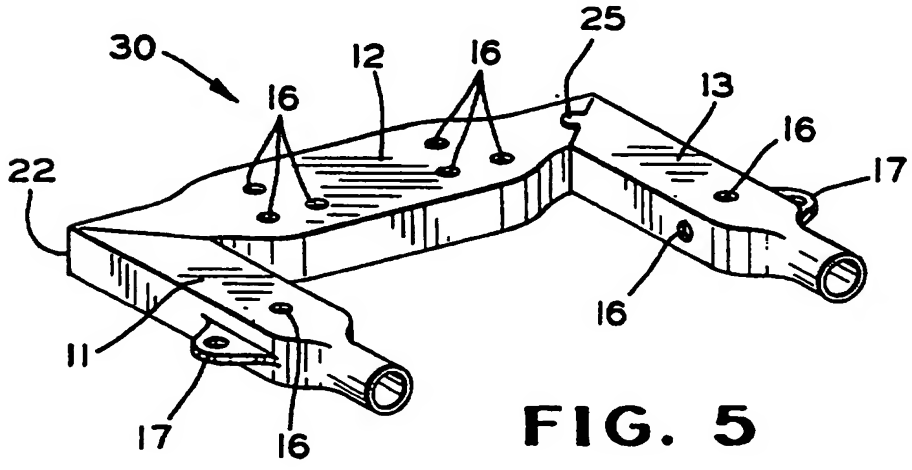
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FIG. 5

TITLE

METHOD OF MANUFACTURING A HOLLOW VEHICLE FRAME COMPONENT HAVING A SHARP BEND

BACKGROUND OF THE INVENTION

This invention relates in general to vehicular frame components and in particular to a method for manufacturing a hollow vehicle frame component having one or more relatively sharp bends.

Virtually all land vehicles in common use, such as automobiles and trucks, include a frame which serves as a platform upon which the remainder of the vehicle is built. Many vehicle frame structures are known in the art. Most of these known vehicle frame structures are formed from a number of individual metallic components which are permanently joined together. One type of vehicle frame structure is known as a full perimeter frame assembly. A typical full perimeter frame assembly is composed of a pair of longitudinally extending side rails which are joined together at the front by a forward cross member, at the rear by a rearward cross member, and at intermediate locations by one or more intermediate or auxiliary cross members. The cross members not only connect the two side rails together, but also provide desirable lateral and torsional rigidity to the vehicle frame assembly. The full perimeter frame assembly functions as a platform upon which the body and remaining components of the vehicle are supported. A second type of vehicle frame structure is known as a unitized frame assembly. In a typical unitized frame assembly, the siderails of the frame assembly are also an integral part of the body of the vehicle. Thus, the body of the vehicle takes the place of the cross members to provide the desired lateral and torsional rigidity to the frame assembly. A third type of vehicle frame structure is known as a cradle frame assembly. A typical cradle frame assembly typically includes a pair of siderails, which extend for only a relatively short portion of the length of the vehicle, and one or more transverse cradles for supporting the components of the vehicle thereon.

In these and other types of vehicle frame assemblies, the frame components may be formed from either open or closed channel structural members. Open channel structural members can be characterized as having a non-continuous cross sectional shape, such as C-shaped or hat-shaped channel members, for example. In the past, most of the vehicle frame components were formed from open channel structural members which were shaped and secured together to form the vehicle frame assembly. Such open channel structural members were relatively easy and inexpensive to shape into desired configurations and to secure together. More recently, however, it has been found desirable to form many of the vehicle frame components from closed channel structural members. Closed channel structural members can be characterized as having a continuous cross sectional shape, such as tubular or box-shaped channel members, for example. Closed channel structural members are desirable because they are generally stronger and more rigid than open channel structural members of comparable weight.

Unfortunately, it has been found to be relatively difficult to shape closed channel structural members into desired configurations, particularly when the desired configuration contains one or more relatively sharp bends. In the past, a conventional mechanical bending machine, such as a tube bender, has been used to apply sufficient forces to the closed channel structural member as to deform it to a desired angle. However, the amount by which a closed channel structural member may be deformed by a conventional tube bender or similar mechanical bending machine is limited. Excessive bending can result in fracturing or other damage to the closed channel structural member. This is particularly true when the size of the closed channel structural member is relatively large, as is typically found in vehicle frame components. When attempting to form a relatively sharp bend in a relatively large closed channel structural member, excessive compression occurs at the inner bending radius, while excessive stretching occurs at the outer bending radius of the tube. This generally results in undesirable buckling of the closed channel structural member at the inner bending surface and undesirable stretching or fracturing of the closed channel structural member at the outer bending radius. Thus, it would be desirable to

provide a method of manufacturing a hollow vehicle frame component which facilitates the formation of a relatively sharp bend therein.

SUMMARY OF THE INVENTION

This invention relates to a method of manufacturing a hollow vehicle frame component having at least one relatively sharp bend. The method may include the initial step of pre-forming a generally linear, hollow member into a desired configuration. The hollow member may be expansion shaped by a hydroforming process. Next, a section of the hollow pre-formed member is removed at a location where it is desired to provide a relatively sharp bend. The section is removed along a portion of the pre-formed member so as to divide it into two sections, thereby forming a hinge-like structure therebetween. The two sections are then bent toward one another such that the edges adjacent the removed section are moved toward one another. Finally, the adjacent edges are secured together to form the vehicle frame component. Portions of the edges may abut one another or overlap one another for securement. A plurality of such bends may be formed in the hollow member. The ends of the hollow member may extend within a single plane or within different planes. The magnitude of the angle formed in the member is dependent upon the sized of the section which is removed therefrom.

Various objects and advantages of this invention will become apparent to those skilled in the art from the following detailed description of the preferred embodiment, when read in light of the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is perspective view of a hollow member adapted to be shaped into a vehicle frame component in accordance with the method of this invention.

Fig. 2 is a perspective view of the hollow member illustrated in Fig. 1 after having been initially pre-formed into a desired shape, such as by hydroforming.

Fig. 3 is a perspective view of the pre-formed hollow member illustrated in Fig. 2 showing the removal of a pair of wedge-shaped sections therefrom.

Fig. 4 is a perspective view of the pre-formed hollow member illustrated in Fig. 3 showing a first end thereof being bent to form a first relatively sharp bend.

Fig. 5 is a perspective view of the pre-formed hollow member illustrated in Fig. 4 showing a second end thereof being bent to form a second relatively sharp bend.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, there is illustrated in Figs. 1 through 5 a method for manufacturing a vehicle frame component in accordance with this invention. Initially, a closed channel workpiece, such as the hollow tubular member indicated generally at 10 in Fig. 1, is provided. The illustrated hollow tubular member 10 is generally straight, has a substantially uniform wall thickness, and defines a substantially uniform outer diameter, although such is not necessary. Although a hollow tubular member 10 is shown in the illustrated embodiment, it will be appreciated that the workpiece may have other closed cross sectional configurations, such as square or rectangular. Also, the workpiece may be formed from a single piece of material as shown, or may be fabricated from two or more pieces of material which are secured together, such as by welding. For the purpose of illustrating the steps in the method of this invention, the hollow tubular member 10 may be viewed as being divided into a first end 11, a center section 12, and a second end 13, as shown by the dotted lines in Figs. 1 through 5. The hollow tubular member 10 is preferably formed a relatively rigid, but deformable material, such as steel or other metallic materials. While steel is preferred, other suitable materials can be used, such as aluminum and aluminum-based alloys, steel based alloys, fiber-matrix composites, and combinations thereof.

The second step in the method of this invention is to deform the hollow tubular member 10 into a pre-formed hollow member, indicated generally at 15 in Fig. 2, having a desired cross-sectional and lengthwise shape. For example, it is often desirable to form some or all of the pre-formed hollow member 15 as to have a generally rectangular or box-shaped cross sectional shape so as to provide the strength and rigidity to the overall vehicle frame assembly, as well as to facilitate the

attachment of other components of the vehicle thereto. Because of various reasons, including vehicle packaging configurations and clearance specifications, it may be necessary that the cross sectional shape of the pre-formed hollow member 15 vary over the length thereof. Accordingly, this second step of the method (which is optional) is performed to achieve the desired cross sectional and lengthwise shape of the final vehicle frame component to be formed.

The pre-formed hollow member 15 illustrated in Fig. 2 may be formed using a hydroforming process. Hydroforming is a well known process which uses pressurized fluid to deform the tubular member 10 into a desired shape. To accomplish this, the tubular member 10 is initially disposed between two die sections of a hydroforming apparatus which, when closed together, define a die cavity having a desired final shape for the pre-formed hollow member 15. Although the die cavity is usually somewhat larger than the tubular member 10 itself, the closure of the two die sections may, in some instances, cause some mechanical deformation of the tubular member 10. Thereafter, the tubular member 10 is filled with a pressurized fluid, typically a relatively incompressible liquid such as water. The pressure of the fluid is increased to a magnitude where the tubular member 10 is expanded outwardly into conformance with the die cavity. As a result, the tubular member 15 is deformed into the desired pre-formed member 15 illustrated in Fig. 2. Alternatively, the pre-formed hollow member 15 may be formed using other techniques, such as stamping, die casting, welding, forging, and combinations thereof.

During the hydroforming process, one or more holes 16 may be formed through the pre-formed hollow member 15. These holes 16 are provided to facilitate attachment of other components to the pre-formed hollow member 15. Alternatively, the holes 16 may be formed after the hydroforming process in any conventional manner, such as by punching or drilling. Similarly, one or more mounting ears 17 may be integrally formed on the pre-formed hollow member 15 during the hydroforming process. These mounting ears 17 may alternatively be formed as separate members which are attached to the pre-formed hollow member 15 in a conventional manner, such as by welding.

Once the pre-formed hollow member 15 is formed, the third step in the method of this invention is to is to remove one or more sections from the pre-formed hollow member 15, as shown in Fig. 3. In the illustrated embodiment, two wedge-shaped sections 20 and 21 may be cut or otherwise removed from the pre-formed hollow member 15. The illustrated pre-formed hollow member 15 is rectangular in cross sectional shape. Thus, each of the illustrated wedge-shaped sections 20 and 21 is defined by a triangularly shaped horizontal upper surface, a rectangularly shaped vertical side surface, and a triangularly shaped horizontal lower surface. As shown in Fig. 3, the first wedge-shaped section 20 is removed from the upper, front, and lower panels of the pre-formed hollow member 15 at the junction between the first end 11 and the central section 12, without affecting the remaining rear panel. In this manner, a first vertically extending hinge-like structure 22 is provided on the pre-formed hollow member 15. The removal of the first wedge-shaped section 20 results in the formation of a first U-shaped edge 20a about the first end 11 of the pre-formed hollow member 15 adjacent to the center section 12, and a second U-shaped edge 20b about the center section 12 of the pre-formed hollow member 15 adjacent to the first end 11. Similarly, the second wedge-shaped section 21 is removed from the upper, front, and lower panels of the pre-formed hollow member 15 at the junction between the central section 12 and the second end 13, without affecting the remaining rear panel. In this manner, a second vertically extending hinge-like structure 23 is provided on the pre-formed hollow member 15. The removal of the second wedge-shaped section 21 results in the formation of a third U-shaped edge 21a about the center section 12 of the pre-formed hollow member 15 adjacent to the second end 13, and a fourth U-shaped edge 21b about the second end 13 of the pre-formed hollow member 15 adjacent to the center section 12.

The wedge-shaped sections 20 and 21 are removed from locations of the pre-formed hollow member 15 where it desired to provide a relatively sharp bend therein. Any conventional cutting technique and equipment may be used to remove the wedge shaped sections 20 and 21, such as a saw, a mechanical punch, or an acetylene torch. Alternatively, the wedge shaped sections 20 and 21 may be partially or completely

removed during the hydroforming process. To accomplish this, the die cavity of the hydroforming apparatus may include cutting edges at locations at which it is desired to remove the wedge shaped sections 20 and 21. As the hollow tubular member 10 is expanded under the influence of the pressurized hydroforming fluid as described above, the outer surface of the member 10 is moved into engagement with the cutting edges. This results in the wedge shaped sections 20 and 21 being partially or completely cut at those locations of the pre-formed hollow member 15. Although the illustrated sections 20 and 21 are wedge shaped, it will be appreciated that the shape of the removed sections 20 and 21 may vary as desired.

It will be appreciated that sizes and shapes of the section 20 and 21 may vary with the cross sectional shape of the pre-formed hollow member 15. While many vehicle frame components have the illustrated rectangular cross sectional shape, it may be desirable to have a frame member having a different cross sectional shape. For example, the frame member may be formed having a tubular, pentagonal, hexagonal, or octagonal cross sectional shape. For these alternative cross sectional shapes, the method of this invention can be practiced by removing a section from the pre-formed hollow member 15 having a shape which is different from the wedge shaped sections 20 and 21. Generally, it will be desirable that the shape of the section which is removed from the pre-formed hollow member 15 provide a relatively straight portion which functions similarly to the illustrated hinge-like structures 22 and 23. Also, the shape of the section to be removed may be irregular in shape. For example, as shown in Figs. 3, 4, and 5, the shape of the section to be removed can be configured to be leave one or more tabs 25 on the remaining portion of the pre-formed hollow member 15. The tabs 25 may be used to facilitate the securement of the adjacent edges 20a, 21a and 20b, 21b of the end sections 11 and 13 to the center section 12.

The fourth step in the method of this invention is to bend the first and second ends 11 and 13 relative to the central section 12 to achieve the desired bends in the vehicle frame component to be manufactured. As shown in Fig. 4, the first end 11 is bent about the first hinge-like structure 22 until the first U-shaped edge 20a (formed on the first end 11 by the removal of the first wedge shaped section 20) abuts the

second U-shaped edge 20b (formed on the center section 12 by the removal of the first wedge shaped section 20). Similarly, as shown in Fig. 5, the second end 13 is bent about the second hinge-like structure 23 until the third U-shaped edge 21a (formed on the second end 13 by the removal of the second wedge shaped section 21) abuts the fourth U-shaped edge 21b (formed on the center section 12 by the removal of the second wedge shaped section 21). Alternatively, the edges 20a, 20b and 21a, 21b may partially or completely overlap one another. It may be desirable to at least partially enclose the adjacent edges 20a, 20b and 21a, 21b with a sleeve or bracket (not shown) which has a configuration similar to the desired sharp bend.

The final step of the method is to secure the adjacent edges 20a, 20b and 21a, 21b together to form the vehicle frame component. This may be accomplished by any conventional means, such as by welding, rivets, bolts, adhesive bonding material, and the like. In addition, a bracket (not shown), such as saddle bracket may be welded or otherwise attached to the hinged joint to provide additional strength.

One result of the method described above is the vehicle frame component 30 illustrated in Fig. 5. As shown therein, the vehicle frame component 30 is a cradle frame in which the two ends 11 and 13 function as siderails and the center section 12 functions as a cross member. The two siderails 11 and 13 extend transversely from the cross member 12 at a bend angle of approximately 90°. Typically, a cradle vehicle frame 30 may be used to support a large or heavy component of the vehicle, such as an engine or transmission (not shown). Accordingly, the cradle frame 30 may include mounting bracket portions 31 formed integrally therewith or otherwise secured thereto. As mentioned above, the plurality of apertures 16 and mounting ears 17 provided on the cradle frame 30 facilitate the mounting the engine or other vehicle components thereon. It will be appreciated that the illustrated cradle frame 30 represents only one example of a vehicle frame component or other article which can be manufactured according to the method of this invention.

In the illustrated embodiment, the two bends which are formed in the pre-formed hollow member 15 are oriented such that the first end 11, the center section 12, and the second end 13 all lie in a single plane. It will be appreciated, however,

that the method of this invention may be performed such that one or more portions of the pre-formed hollow member 15 may be bent so as to extend in different planes. Also, the angles defined between the bent sections may vary as desired. In general, the finished vehicle frame component manufactured in accordance with this invention may have any desired cross sectional shape and may vary in size and shape throughout its length.

Lastly, in some instances, it may be desirable to bend the pre-formed hollow member 15 so as to only partially close the gap defined between the adjacent edges 20a, 20b and 21a, 21b, as opposed to fully closing the gap therebetween, as illustrated. For example, it may be desirable to bend the first end 11 partially relative to the center section 12 such that a gap remains between the edges 20a and 20b. The edges 20a and 20b may be connected together by one or more separate plates (not shown) which are welded or otherwise secured thereto. For the purposes of this invention, securement of the edge 20a of the first end 11 to the edge 20b of the center section 12 includes not only direct securement, but also the provision of an intermediate plate or other connecting structure between such edges 20a and 20b.

In accordance with the provisions of the patent statutes, the principle and mode of operation of this invention have been explained and illustrated in its preferred embodiment. However, it must be understood that this invention may be practiced otherwise than as specifically explained and illustrated without departing from its spirit or scope.

CLAIMS

1. A method for manufacturing a hollow vehicle frame component comprising the steps of:

(a) providing a generally hollow member;

(b) removing a section of the hollow member so as to form a hinge-like structure extending between edges of the hollow member;

(c) bending the hollow member at the hinge-like structure; and

(d) securing the edges of the hollow member together.

2. The method defined in Claim 1 wherein said step (a) includes the step of expanding the hollow member into conformance with a die cavity having a desired shape and size for the hollow member.

3. The method defined in Claim 2 wherein said step of expanding the hollow member includes the step of providing a highly pressurized fluid within said hollow member.

4. The method defined in Claim 1 wherein the hollow member is provided having a generally rectangular cross sectional shape, including a front panel, a rear panel, an upper panel, and a lower panel.

5. The method defined in Claim 4 wherein the section is removed from portions of three of the four panels.

6. The method defined in Claim 5 wherein the section is a generally wedge-shaped.

7. The method defined in Claim 1 wherein said step (c) includes bending the hollow member until portions of the edges thereof abut one another.

8. The method defined in Claim 1 wherein said step (c) includes bending the hollow member until portions of the edges thereof overlap one another.

9. A method for manufacturing a hollow vehicle frame component substantially as described herein with reference to the accompanying drawings.

The Patent Office

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Application No: GB 9725971.7 **Examiner:** A.R.Martin
Claims searched: All claims **Date of search:** 9 February 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): B3A

Int Cl (Ed.6): B21D 47/00,B21K 1/00,B62D 21/00

Other: On line databases WPI,EDOC,JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB 2281047 A	A.O.Smith see claim 2	Claim 1 at least
X,Y	GB 832432	Spiegelman see Figs 1 and 2	"
Y	WO 96/19373 A	Cosma see claim 13	"

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
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E Patent document published on or after, but with priority date earlier than, the filing date of this application.